T01D09 – Unit Exam

Name KEY

Part I – Multiple Choice (STD 6 – Structure and Properties of Matter)

1. What amount of oxygen, O_2, (in moles) contains 1.8×10^{22} molecules?

A. 0.0030
B. 0.030
C. 0.30
D. 3.0

$1.8\times10^{22}\ mc\ O_2 \times \frac{1\ mol\ O_2}{6.022\times10^{23}\ mc\ O_2} = 0.0299 \Rightarrow 0.030$ (2 sig figs)

(1)

2. How many oxygen atoms are present in 0.0500 mol carbon dioxide?

A. 3.01×10^{22}
B. 6.02×10^{22}
C. 6.02×10^{23}
D. 1.20×10^{24}

$0.0500\ mol\ CO_2 \times \frac{6.022\times10^{23}\ mc\ CO_2}{1\ mol\ CO_2} \times \frac{2\ atoms\ O}{1\ mc\ CO_2} = 6.022\times10^{22}\ atoms\ O$

(1)

3. What amount of NaCl (in moles) is required to prepare 250 cm^3 of a 0.200 mol dm^{-3} solution?

A. 50.0
B. 1.25
C. 0.800
D. 0.0500

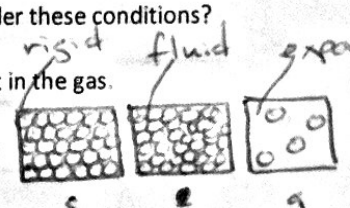
$\frac{0.200\ mol}{dm^3} = 0.200\ M\ NaCl = \frac{x\ mol\ NaCl}{0.250\ L}$ $\quad x = 0.0500\ mol\ NaCl$

$250\ cm^3 = 250\ mL = 0.250\ L$

(1)

4. Solid, liquid and gaseous water are all present at very low pressure near 0°C.
How do the distances between the molecules in the three states compare under these conditions?

A. The distances are equal in all three states.
B. Distances are similar in the solid and liquid, which are smaller than that in the gas.
C. Distances are smallest in the solid, and similar in the liquid and gas.
D. Distances are smallest in the liquid, and similar in the solid and the gas.



(1)

5. Which of the following contains the greatest number of molecules?

A. 1 g of H_2SO_4 MW = 98.09 g/mol
B. 1 g of H_3PO_4 MW = 98.00 g/mol
C. 1 g of $HClO_4$ MW = 100.46 g/mol
D. 1 g of Na_2CO_3 MW = 105.97 g/mol

take extremes:
$1\ g\ Na_2CO_3 \times \frac{1\ mol\ Na_2CO_3}{105.97\ g\ Na_2CO_3} = 0.009\ mol\ Na_2CO_3$
$1\ g\ H_3PO_4 \times \frac{1\ mol\ H_3PO_4}{98.00\ g\ H_3PO_4} = 0.01\ mol\ H_3PO_4$ → mc

(1)

6. What will happen to the volume of a fixed mass of gas when its pressure and temperature (in Kelvin) are both doubled?

A. It will not change.
B. It will increase.
C. It will decrease.
D. The change cannot be predicted.

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ Ex: $\frac{(1\ atm)(1\ L)}{(273\ K)} = \frac{(2\ atm)(V_2)}{(546\ K)}$

$V_2 = 1\ L$

(1)

7. ~~In which gas sample do molecules have the greatest average kinetic energy?~~

~~A. H_2 at 100 K~~
~~B. CH_4 at 273 K~~
~~C. H_2O at 373 K~~
~~D. CH_3OH at 353 K~~

Not a fair Question. Good question, but we have not covered yet!

(1)

8. Consider the following equation.

$2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(l)$

How many moles of $CO_2(g)$ are produced by the complete combustion of 58 g of butane, C_4H_{10} (g)?

A. 4
B. 8
C. 12
D. 16

$58\ g\ C_4H_{10} \times \frac{1\ mol\ C_4H_{10}}{58.14\ g\ C_4H_{10}} \times \frac{8\ mol\ CO_2}{2\ mol\ C_4H_{10}} = 3.99 \rightarrow 4.0\ mol\ CO_2$ (2 sig figs.)

(1)

9. Which solution contains the greatest amount (in mol) of solute?

A. 10.0 cm^3 of 0.500 mol dm^{-3} NaCl $0.5000\,M = \frac{x\ mol\ NaCl}{0.0100\,L}$ 0.0050 mol

B. 20.0 cm^3 of 0.400 mol dm^{-3} NaCl $0.400\,M = \frac{x\ mol\ NaCl}{0.0200\,L}$ 0.008 mol

C. 30.0 cm^3 of 0.300 mol dm^{-3} NaCl $0.300\,M = \frac{x\ mol\ NaCl}{0.0300\,L}$ 0.009 mol

D. 40.0 cm^3 of 0.200 mol dm^{-3} NaCl $0.200\,M = \frac{x\ mol\ NaCl}{0.0400\,L}$ 0.008 mol

(1)

10. How many hydrogen atoms are contained in one mole of ethanol, C_2H_5OH?

A. 5

B. 6

C. 1.0×10^{23}

D. 3.6×10^{24}

$1\,mol\ C_2H_5OH \times \frac{6.022\times10^{23}\ mc}{1\,mol\ C_2H_5OH} \times \frac{6\ atoms\ H}{1\,mc\ C_2H_5OH} = 3.6\times10^{24}$

(1)

11. Which compound has the empirical formula with the greatest mass?

A. CH_3OH $CH_4O = 32.05$

B. $C_6H_{12}O_6$ $CH_2O = 30.03$

C. CO_2 $CO_2 = 44.01$

D. C_8H_{12} $C_2H_3 = 27.05$

(1)

12. 8.5 moles of $Fe_2O_3(s)$ reacts with 9.0 moles of carbon in a blast furnace according to the equation below.

$$Fe_2O_3(s) + 3C(s) \rightarrow 2Fe(s) + 3CO(g)$$

What is the limiting reagent and hence the theoretical yield of iron?

no correct answer.

	Limiting reagent	Theoretical yield of iron
A.	Fe_2O_3	4.8×10^2 g
B.	Fe_2O_3	2.4×10^2 g
C.	carbon	2.5×10^2 g
D.	carbon	1.7×10^2 g

Freebie! ☺

(1)

13. Consider the equation below.

$$Fe(s) + S(s) \rightarrow FeS(s)$$

If 10.0 g of iron is heated with 10.0 g of sulfur to form iron(II) sulfide, what is the theoretical yield of FeS in grams?

A. 10.0 + 10.0

B. $\frac{87.91\times10.0}{55.85}$

C. $\frac{87.91\times10.0}{32.06}$

D $\frac{55.85\times10.0}{32.06}$

$10.0\,g\ Fe \times \frac{1\,mol\ Fe}{55.85\,g\ Fe} \times \frac{1\,mol\ FeS}{1\,mol\ Fe} \times \frac{87.91\,g\ FeS}{1\,mol\ FeS} = 15.7\,g$ Limiting

$10.0\,g\ S \times \frac{1\,mol\ S}{32.06\,g\ S} \times \frac{1\,mol\ FeS}{1\,mol\ S} \times \frac{87.91\,g\ FeS}{1\,mol\ FeS} = 27.4\,g$

(1)

14. Which change in conditions would increase the volume of a fixed mass of gas?

	Pressure / kPa	Temperature / K
A.	Doubled	Doubled
B.	Halved	Halved
C.	Doubled	Halved
D.	Halved	Doubled

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

T↑ P↓

(1)

15. Under what conditions would one mole of methane gas, CH_4, occupy the smallest volume?

A. 273 K and 1.01×10^5 Pa

B. 273 K and 2.02×10^5 Pa

C. 546 K and 1.01×10^5 Pa

D. 546 K and 2.02×10^5 Pa

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

T↓ P↑

(1)

16. Which of the following compounds has/have the empirical formula CH_2O?

I. CH_3COOH CH_2O
II. $C_6H_{12}O_6$ CH_2O
III. $C_{12}H_{22}O_{11}$ $C_{12}H_{22}O_{11}$

A. II only
B. III only
C. I and II only
D. II and III only

(1)

17. The percentage by mass of the elements in a compound is
Ca = 54.05%, H = 2.70 %, O = 43.24%.
What is the mole ratio of Ca : H in the empirical formula of this compound?

A. 1 : 1
B. 1 : 2
C. 1 : 6
D. 6 : 1

$54.05\,g\,Ca \times \frac{1\,mol\,Ca}{40.08\,g\,Ca} = 1.35\,mol\,Ca$ $43.24\,g\,O \times \frac{1\,mol\,O}{16.00\,g\,O} = 2.70\,mol\,O$

$2.70\,g\,H \times \frac{1\,mol\,H}{1.01\,g\,H} = 2.67\,mol\,H$

$\frac{Ca_{1.35}O_{2.70}H_{2.67}}{1.35} \approx Ca(OH)_2$

(1)

18. $2\,C_3H_7OH(g) + 9\,O_2(g) \rightarrow 6\,CO_2(g) + 8\,H_2O(g)$
When the equation above is balanced, what is the coefficient for oxygen?

A. 5
B. 8
C. 9
D. 10

(1)

19. 5.0 dm^3 of sulfur dioxide is reacted with 4.0 dm^3 of oxygen according to the equation below.
$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$

What volume of sulfur trioxide (in dm^3)is formed? (Assume the reaction goes to completion and all gases are measured at the same temperature and pressure)

A. 5.0
B. 4.0
C. 6.0
D. 8.0

$5.0\,L\,SO_2 \times \frac{2\,mol\,SO_3}{2\,mol\,SO_2} = 5.0\,L\,SO_3$ ← 1:1 ratio!

$4.0\,L\,O_2 \times \frac{2\,mol\,SO_3}{1\,mol\,O_2} = 8.0\,L\,SO_3$

(1)

20. What volume (in dm^3) of 0.30 mol dm^{-3} NaCl solution can be prepared from 0.060 mol of solute?

A. 0.018
B. 0.20
C. 0.50
D. 5.0

$\frac{0.300\,mol}{dm^3} = 0.30\,M\,NaCl = \frac{0.06\,mol}{x\,L}$

$x = 0.20\,L = 0.20\,dm^3$

(1)

21. A hydrocarbon contains 90 % by mass of carbon. What is its empirical formula?

A. CH_2
B. C_3H_4
C. C_7H_{10}
D. C_9H_{10}

$90\,g\,C \times \frac{1\,mol\,C}{12.01\,g\,C} = 7.5\,mol\,C$

$10\,g\,H \times \frac{1\,mol\,H}{1.01\,g\,H} = 9.9\,mol\,H$

$\frac{C_{7.5}H_{9.9}}{7.5} = CH_{1.33}$ (×3) → C_3H_4

(1)

22. Lithium hydroxide reacts with carbon dioxide as follows.
$2LiOH + CO_2 \rightarrow Li_2CO_3 + H_2O$

What mass (in grams) of lithium hydroxide is needed to react with 11 g of carbon dioxide?

A. 6
B. 12
C. 24
D. 48

$11\,g\,CO_2 \times \frac{1\,mol\,CO_2}{44.0\,g\,CO_2} \times \frac{2\,mol\,LiOH}{1\,mol\,CO_2} \times \frac{23.95\,g\,LiOH}{1\,mol\,LiOH} = 11.97\,g\,LiOH$

(1)

Li - 6.94
H - 1.01
O - 16
} 23.95 g/mol = LiOH

2 sig figs.
= 12 g LiOH

Part II – Free Response Questions (STD 10 – Collects and Processes Data)

23. 100 cm^3 of ethene, C_2H_4, is burned in 400 cm^3 of oxygen, producing carbon dioxide and some liquid water. Some oxygen remains unreacted.

(a) Write the equation for the complete combustion of ethene.

$C_2H_4 + 3O_2 \longrightarrow 2CO_2 + 2H_2O$ **(2)**

(b) Calculate the volume of carbon dioxide produced and the volume of oxygen remaining.

NOT STP

$100\,mL\ C_2H_4 \times \frac{1\,L\ C_2H_4}{1000\,mL\ C_2H_4} \times \frac{1\,mol\ C_2H_4}{22.4\,L\ C_2H_4} \times \frac{2\,L\ CO_2}{1\,L\ C_2H_4} = 0.2\,L$ a 200mL

*Assume all gases @ same conditions.

∴ Avogadro's law can be applied to volumes and use the mole ratio.

$\times \frac{3\,L\ O_2}{1\,L\ C_2H_4} = 0.3\,L$ a 300mL

400 − 300 = 100mL

(1 sig fig needed) **(2)**

(Total 4 marks)

24. (a) Write an equation for the formation of zinc iodide from zinc and iodine.

$Zn + I_2 \longrightarrow ZnI_2$

*I_2 (not I) b/c iodine is diatomic (BrINClHOF). **(1)**

(b) 100.0 g of zinc is allowed to react with 100.0 g of iodine producing zinc iodide.

Calculate the amount (in moles) of zinc and iodine, and hence determine which reactant is in excess.

$100\,g\ Zn \times \frac{1\,mol\ Zn}{65.41\,g\ Zn} = 1.529\,mol\ Zn$ = Excess

both 1:1 w/ ZnI_2

$100\,g\ I_2 \times \frac{1\,mol\ I_2}{253.8\,g\ I_2} = 0.392\,mol\ I_2$ = Limiting max yield.

(3)

(c) Calculate the mass of zinc iodide that will be produced.

$100\,g\ I_2 \times \frac{1\,mol\ I_2}{253.8\,g\ I_2} \times \frac{1\,mol\ ZnI_2}{1\,mol\ I_2} \times \frac{319.2\,g\ ZnI_2}{1\,mol\ ZnI_2} = 125.8\,g\ ZnI_2$

4 s.f.

(1)

(Total 5 marks)

25. (i) Calcium ~~carbonate~~ hydroxide is added to separate solutions of hydrochloric acid and ~~ethanoic~~ acetic acid of the same concentration. Write an equation for each reaction.

$Ca(OH)_2 + 2HCl \longrightarrow CaCl_2 + 2H_2O$

$Ca(OH)_2 + 2HC_2H_3O_2 \longrightarrow Ca(C_2H_3O_2)_2 + 2H_2O$

(2)

(ii) If 5.0g of calcium ~~carbonate~~ hydroxide react with an excess of hydrochloric acid, what is the theoretical yield for calcium chloride?

$5.0\text{ g } Ca(OH)_2 \times \frac{1\text{ mol } Ca(OH)_2}{74.1\text{ g } Ca(OH)_2} \times \frac{1\text{ mol } CaCl_2}{1\text{ mol } Ca(OH)_2} \times \frac{110.98\text{ g } CaCl_2}{1\text{ mol } CaCl_2} = 7.5\text{ g } CaCl_2$

(2 sig figs)

(3)

(iii) If 1.05g of calcium chloride are produced in the lab, calculate the percent yield AND percent error?

$\frac{\text{Experimental}}{\text{Theoretical}} = \%\text{ Yield} = \frac{1.05}{7.5} \times 100 = 14\%$ (2 sig figs)

$\left|\frac{\text{Theoretical} - \text{Experimental}}{\text{Theoretical}}\right| \times 100 = \%\text{ error} = \left|\frac{7.5 - 1.5}{7.5}\right| \times 100 = 86\%$

(iv) Calculate the volume of ~~carbon dioxide~~, measured at 273 K and

1.01×10^5 Pa, which would be produced when ~~1.25 g~~ 5.0 g of calcium ~~carbonate~~ hydroxide reacts completely with the hydrochloric acid.

$P = 1\text{ atm}$

$T = 273\text{ K}$

$n = 5.0\text{ g } Ca(OH)_2 \times \frac{1\text{ mol } Ca(OH)_2}{74.1\text{ g } Ca(OH)_2} \times \frac{2\text{ mol } H_2O}{1\text{ mol } Ca(OH)_2} = 0.135\text{ mol } H_2O$

$R = 0.0821\ \frac{\text{L·atm}}{\text{mol·K}}$

$V = ?$

* must use & find mol of H_2O as that is the species we are to find the volume of.

(2)

(Total 9 marks)

$PV = nRT$

$V = \frac{nRT}{P} = \frac{(0.135\text{ mol})\left(0.0821\ \frac{\text{L atm}}{\text{mol K}}\right)(273\text{ K})}{(1\text{ atm})}$

$= 3.0\text{ L } H_2O$

↳ 2 sig figs b/c 5.0 g starting material

26. The percentage composition by mass of a hydrocarbon is C = 79.9 % and H = 20.1 %.

(a) Calculate the empirical formula of the hydrocarbon.

*Assume 100g of substance.

$79.9\text{ g C} \times \frac{1\text{ mol C}}{12.01\text{ g C}} = 6.65\text{ mol C}$

$\frac{C_{6.55}H_{2.99}}{2.95} = CH_3$

$20.1\text{ g H} \times \frac{1\text{ mol H}}{1.01\text{ g H}} = 2.99\text{ mol H}$

*divide by smallest to get lowest common denominator.

(2)

(b) A 1.00 g sample of the hydrocarbon at a temperature of 273 K and a pressure of 1.01×10^5 Pa(1.00 atm) has a volume of 0.495 dm^3.

*Molar mass is $\frac{g}{mol}$

So, $\frac{1.00\text{ g}}{0.0221\text{ mol}} = 45.28\text{ g/mol}$

(i) Calculate the molar mass of the hydrocarbon.

$P = 1\text{ atm}$

$V = 0.495\text{ L}$

$n = ?$

$T = 273\text{ K}$

$R = 0.0821 \frac{\text{L·atm}}{\text{mol·K}}$

$PV = nRT$

$n = \frac{PV}{RT} = \frac{(1\text{ atm})(0.495\text{ L})}{(0.0821\frac{\text{L·atm}}{\text{mol·K}})(273\text{ K})} = 0.0221\text{ mol}$

(3 sig figs)

(2)

(ii) Deduce the molecular formula of the hydrocarbon.

$3 \times CH_3 = 45.28\text{ g/mol} \rightarrow C_3H_9$ (not an actual molecule, just an example).

(1)

(Total 5 marks)

*CH_3 has a molar mass of 15.04 g/mol. Three of the empirical formula would be the molecular, so multiply each atom by 3.